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FROM:

DATE: 18 August 1964

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SUBJECT: Alternate Source

Second Source Requirement

As an instrument utilizing the properties of coherent light, the enlarger is designed to operate with a helium-neon laser as the prime source of illumination. The laser fulfills the functions of providing monochrmatic light having full coherence; however, it cannot be said that this source is ideal under all circumstances for purposes of photographic reproduction. Particularly in the light of the preliminary breadboard experimentation, it has become evident that for some purposes light source requirements exist that are not readily fulfilled by the laser. Specifically, the helium-neon laser presents difficulties in the following respects.

1. The degree of coherence is not readily controllable (where departure from full coherence is required).

2. The laser wavelength is not suitable for critical visual test purposes, and for some photographic purposes.

3. Laser output illuminations under some circumstances lead to excessive exposures.

These difficulties are met by providing the enlarger with an alternate illumination source comprised of a sodium vapor lamp in conjunction with an appropriate auxiliary source optical system.

Alternate Source Selection

Alternate source requirements were studied during the course of the enlarger breadboard experiments. Some trials were made with an incandescent lamp is conjunction with a narrow band filter, but it became evident that the lack of chromatic correction in the optical system led to excessive requirements in respect to bandwidth limitation. A zinc vapor lamp was tried briefly — this source having a wavelength close to that of the laser, but with relatively low output and no improvement over the laser in respect to visibility.

The eventual selection was a sodium vapor lamp. This operates at a wavelength of 5890 Å — this being close enough to laser wavelength of 6328 Å so that no optical system color correction problems are encountered.

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Since the color is close to the sensitivity peak of the eye, the visibility function is excellent (five times that of laser light). This is of importance in visual optical test procedures. Finally, this lamp provides a high light output in a bulb size suitable for the required semi-extended source configuration.

Source Description

In the prototype enlarger, the alternate source system is located beneath the laser; and is brought into use, when required, by the actuation of an auxiliary mirror. The alternate source system is shown in the appended sketch.

The sodium lamp, which presents an illumination source of 1/2-inch diameter, is reimaged by a condenser lens pair at an adjustable iris. An isolation filter in the condenser system suppresses the incandescent radiation from the lamp electrodes and eliminates sodium spectrum lines other than the pair at 5890 A. The adjustable iris diaphragm is projected by collimator lenses, and is eventually reimaged at the transform plane of the imaging optical system, the degree of coherence being regulated by adjusting the iris opening. The collimator lens system is comprised of the main collimator lens (used with the laser source) in conjunction with an auxiliary collimator lens which acts to shorten the effective focal length of the collimator system as required for correct magnification in reimaging the iris.

A separate power supply for the sodium lamp is located in the main control rack. The alternate source illumination is controlled by a separate shutter which is automatically switched into the timing control circuit when the auxiliary mirror is operated.

The sodium vapor and laser sources are quite dissimilar in regard to means of varying coherence and in the relations between degree of coherence and exposure.

From the standpoint of illumination at the film plane, and consequently exposure time, the laser performs most efficiently when used at full coherence. Any means used to reduce coherence will in general also reduce its efficiency as a light source. If, for example, the departure from coherence were obtained by the introduction into the beam of a diffusing plate having a variable degree of diffusion, then the exposure time would increase as the coherence decreased, due to loss of illumination efficiency by diffusion. Curve "B" on the attached chart shows this condition, which is not actually realizable since no suitable variable diffuser is at hand.

In the prototype enlarger, laser coherence is controlled by the use of a special rotating diffuser located at the focal point of the collimator lens and illuminated by the laser beam through a condenser lens used at varying

conjugates. The degree of coherence is determined by the size of the illuminated spot at the diffuser, which is reimaged at the transform plane. On the attached graph, the condition described is shown by curve "A". This indicates that when the laser beam is used without diffusion, that is, at full coherence (or a very slight departure obtainable by defocusing) the optimum exposure time is 16 seconds. When the rotating diffuser is introduced, the exposure is increased to about 150 seconds, and remains at this value irrespective of variations of coherence obtained by varying the spot size.

In the alternate (sodium lamp) source, the degree of coherence is determined by the opening of the iris diaphragm allowing an adjustment of from 95 percent to 75 percent coherence. The illuminated iris is reimaged at the transform plane at a magnification of 0.66. At the transform plane, the aperture diameter, D, is 2.52 inches and admits a spatial frequency range up to 220 lines per millimeter. With a given reimaged spot size, d, at the transform plane, the departure from full coherence in percent is then given by:

$$\omega = \frac{d}{D}, \text{ or}$$

$$\omega = \frac{d}{2.52}$$

The coherence factor is then easily determined by measurement of either the iris or the transform plane spot diameter.

When the alternate source is used, the exposure time varies simply as the inverse square of the iris diameter, that is:

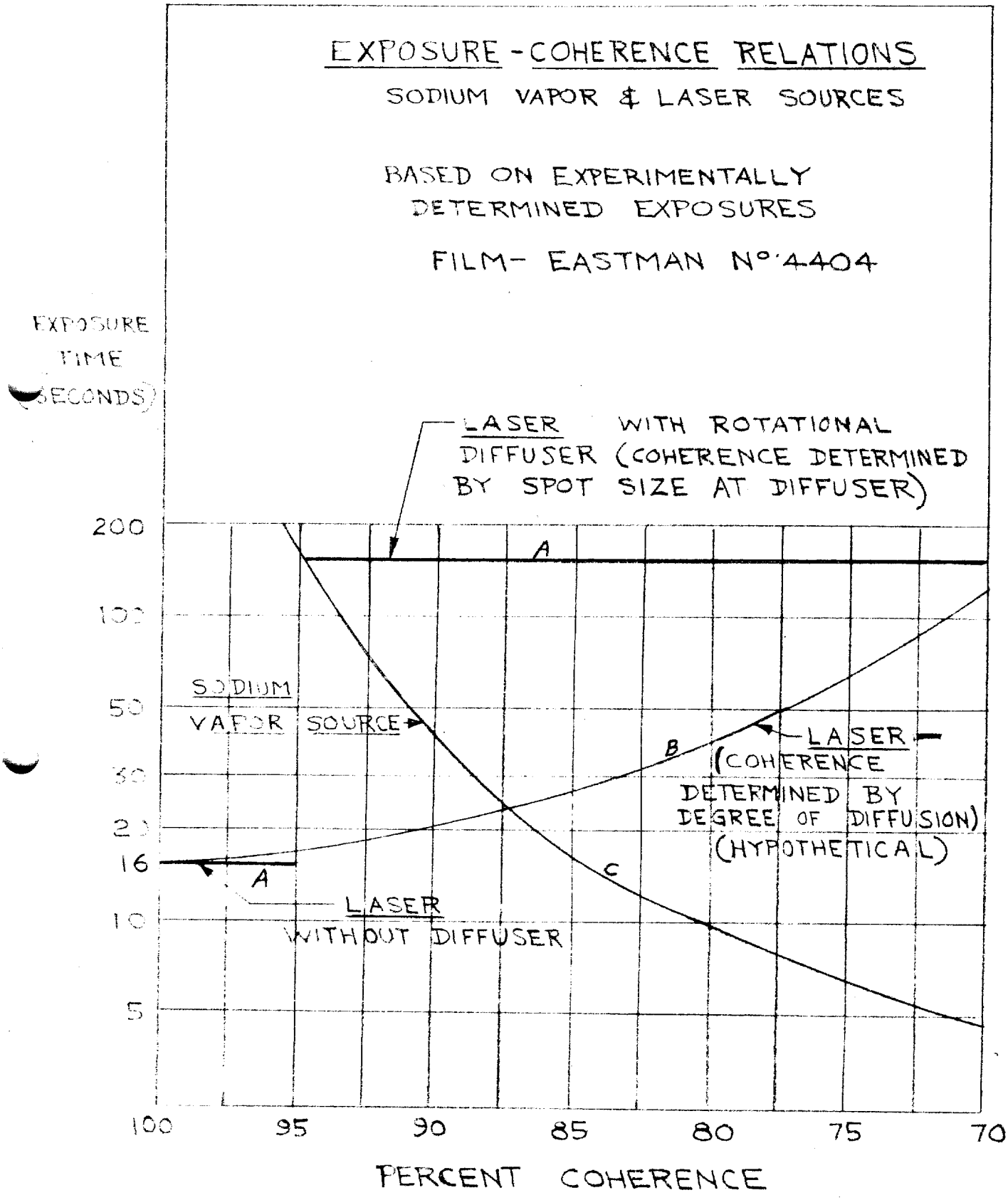
$$td^2 = \text{a constant}$$

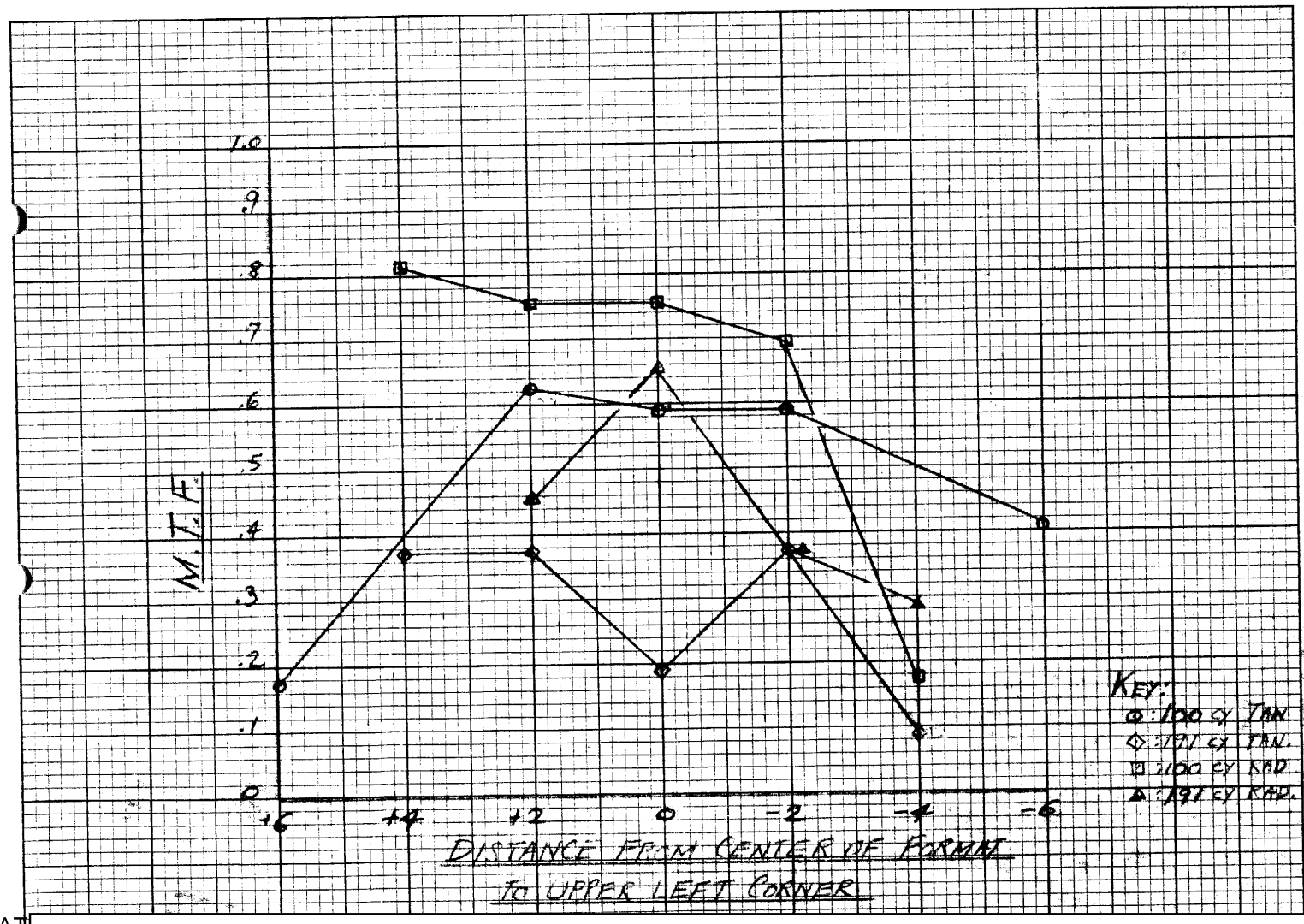
This relation is shown by curve "C" on the graph, which is based on experimental results using No. 4404 film.

Summary

As an adjunct to the laser as a primary source of illumination, an auxiliary source is available, based on a sodium vapor lamp. It is expected that this additional source system will be of value in certain operational and experimental work, particularly in providing:

1. A readily controllable and measurable amount of coherence.
2. A source having a high visibility function.
3. Shorter exposure times than those obtainable with the laser (at less than full coherence).





7 August 1964

STAT [redacted] WEEKLY PROGRESS REPORT

This week was spent in an attempt to obtain the Modulation Transfer Function of the enlarger under varying lighting conditions. Unfortunately this information has been difficult to obtain because our light sources and our film processing procedures are not "in the books". Results are summarized below:

A. SO-243 Film developed in diluted D-76 for which no transfer function information is available. Assume values shown in column b:

A Spatial Frequency of Target	B Film Transfer Function (Assumed)	C System Transfer Function: Laser, Partial Diffuser	D System Transfer Function: Laser, Full Diffuser
50 cy/mm	.90	1.39	1.27
100	.83	.92	.70
191	.70	1.22	1.12

B. Assume transfer function of film is unity and normalize on basis that item 50C should also be unity:

A	B	C	D
50	1.00	1.00	.91
100	1.00	.61	.46
191	1.00	.68	.63

The apparent drop in the transfer function at 100 cycles per mm is due to the fact that the three targets were simultaneously spread out in the field and the 100 cycle target was at a point of poor resolution. The results are plotted on the attached graph; note the word TENTATIVE!

In addition to the above retrofit work was accomplished on the vertical transport drive to permit wider variations of film weight.

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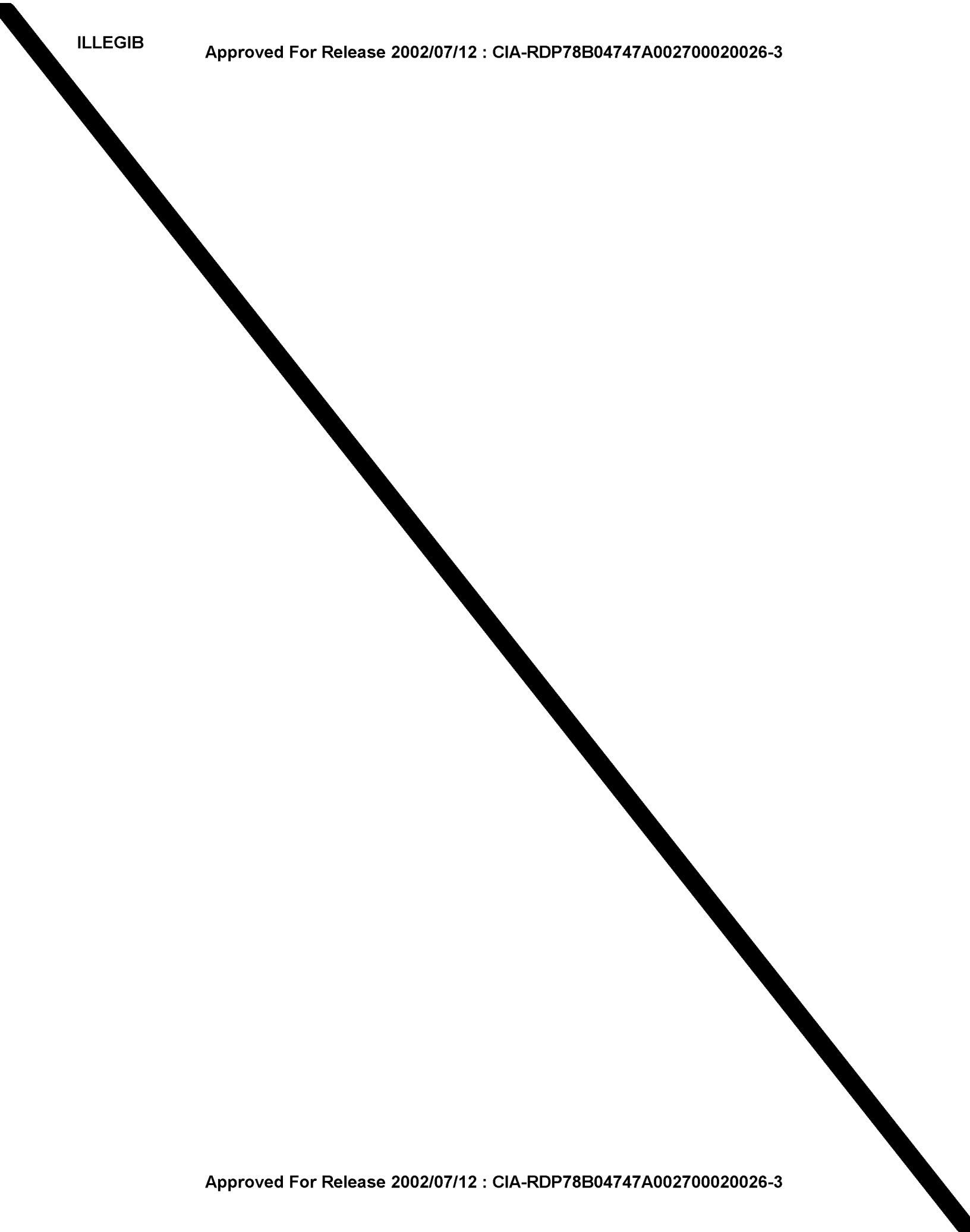

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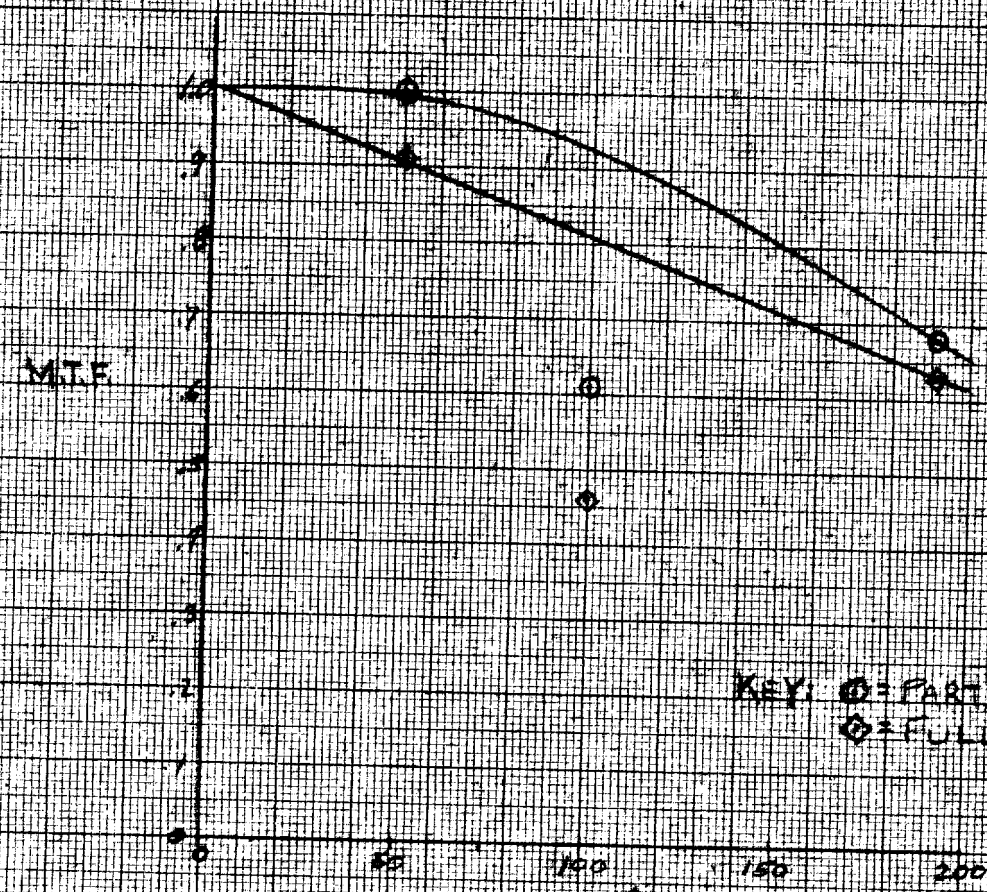
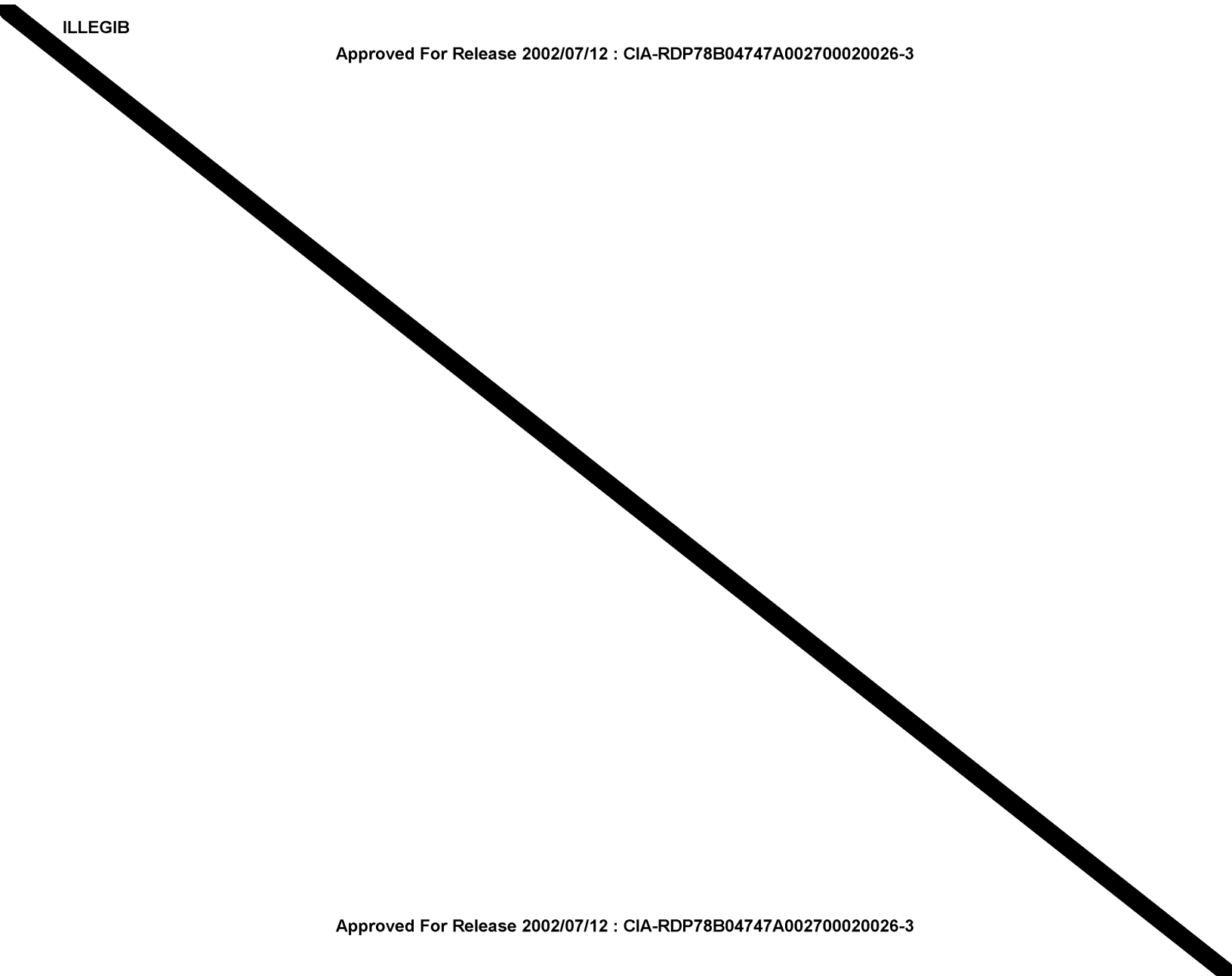
TENTATIVE



MODULATION TRANSFER FUNCTION
VS. SPATIAL FREQUENCY

COMMENT ENLARGER



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